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Correlates of children's physical activity during physical education classes

Abstract

Aim The aim of this study was to investigate the influence of correlates on physical activity (PA) during physical education (PE). **Method** One hundred and ninety children (11.2 ± 0.8 y, 1.5 ± 0.1 m, 37.7 ± 8.3 kg) of 12 classes participated. Children were asked to wear an accelerometer for seven days. Teachers filled in a questionnaire to collect data about correlates of PA during PE (i.e. sex, weight, age of children, daily PA of the children, class size, PA behavior and formation of the teacher and size of gym). Correlates for moderate-to-vigorous PA (MVPA) during PE were determined using multifactor linear regression analysis. **Results** Fifty-three percent of the variability of MVPA during PE was explained by the investigated correlates. Apart from individual correlates (sex, weight, age), PE taught in small classes and large gyms by a PE specialist and a high overall PA of the child had independent positive effects on MVPA during PE. **Conclusion** The results underline the importance of small PE classes taught by specialized PE teachers in large gyms and the increase of overall PA of children for effective future intervention studies and for political discussion focusing on increasing PA during PE.

Zusammenfassung

Ziel Ziel der vorliegenden Studie war, den Einfluss verschiedener Faktoren auf die körperliche Aktivität (kA) von Kindern während des Sportunterrichtes zu untersuchen. **Methode** 190 Kinder (11.2 ± 0.8 y, 1.5 ± 0.1 m, 37.7 ± 8.3 kg) aus 12 Schulklassen nahmen an der Studie teil. Die Kinder wurden gebeten, während 7 Tagen einen Beschleunigungsmesser zu tragen. Mit diesem wurden die kA während des Sportunterrichtes und die allgemeine tägliche Aktivität der Kinder erhoben. Zudem wurden die Lehrer gebeten, einen Fragebogen auszufüllen, zur Erfassung von Geschlecht, Gewicht und Alter der Kinder. Daneben wurden die Klassen- und Turnhallengrösse, das tägliche Aktivitätsverhalten und die Ausbildung des Lehrers erhoben. Der Einfluss der verschiedenen Faktoren auf die moderate bis intensive kA im Sportunterricht wurde mittels multipler linearer Regression berechnet. **Resultate** 53% der Variabilität der moderaten bis intensiven kA im Sportunterricht wurde durch die untersuchten Variablen erklärt. Neben individuellen Faktoren wie Alter, Geschlecht und Gewicht war Sportunterricht, der von einem ausgebildeten Sportlehrer unterrichtet wurde in kleinen Klassen und in grossen Sporthallen, assoziiert mit höherer kA im Sportunterricht. Zudem waren Kinder mit hohem täglichem Aktivitätsverhalten auch im Turnunterricht aktiver. **Diskussion** Die kA der Kinder im Sportunterricht ist bei idealen Bedingungen mit Integration von Experten, kleinen Schulklassen und grossen Turnhallen erhöht, was bei zukünftigen Interventionen und in der politischen Diskussion um den Turnunterricht beachtet werden sollte.

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Introduction

Physical activity (PA) has been shown to be related to a clustering of metabolic risk factors (Kriemler et al., 2008; Andersen et al., 2011), obesity (Kriemler et al., 2008), depression (Biddle and Asare, 2011) and bone mass (Hind and Burrows, 2007). For children to remain healthy, at least 60 minutes of moderate-to-vigorous PA (MVPA) accumulated over the day are recommended (Strong et al., 2005). To increase the number of children meeting these recommendations, various PA interventions have been conducted (Kriemler et al., 2010). As, in contemporary developed societies, all children are obliged to go to school and spend most of the day there, school-based interventions are assumed to have a large potential to increase PA, thereby tackling especially children that are less active.

Usually, school interventions are focused on recess (Stratton and Mullen, 2005) and PE (McKenzie et al., 2001; McKenzie et al. 2004) or include a combination of several components (Kriemler

et al., 2010). Thereby, the focus on PE lessons was especially successful, being able to increase total PA over the day (Kriemler et al., 2010; Meyer et al., 2011). This has been confirmed by research that found children to be more active during school mornings that contained a PE lesson compared to purely academic school days (Meyer et al., 2011). Importantly, the active time gained during PE was not compensated by a reduction of extra-curricular PA time (Meyer et al., 2011). Yet, MVPA accumulated during PE lessons does not meet the recommended (Pate et al., 2006) 50% of the entire lesson time (McKenzie et al., 1995; Nader, 2003). Several observational studies have therefore investigated correlates that might increase PA during PE such as specialized teachers (classroom vs. PE specialist) (McKenzie et al., 1995; McKenzie et al., 2000), the sex of students (McKenzie et al., 1995, 2000; Nader, 2003), lesson's location (McKenzie et al., 1995, 2000; Nader, 2003), leisure time PA behavior of the teacher (McKenzie et al., 1999) and lesson context and content (McKenzie et al., 2000; Nader, 2003). These correlates may be crucial for the optimization of PE lessons

to fulfill PA recommendations and their contribution to total PA. However, the composite effect of a variety of correlates is not known and their effect on objectively measured accelerometer data has still to be investigated. Therefore, the aim of this study was to investigate the influence of a variety of correlates on objectively measured PA during PE.

Materials and Methods

Subjects

The school directors of primary schools of one province comprising 17% of the whole population were contacted via telephone or e-mail and were informed about the study. They were asked to provide this information to the teachers of their schools. Twelve classes of 4th to 6th grade from five villages (2000–5000 inhabitants) and seven small towns (5000–18000 inhabitants) participated in the study. Six of the teachers were classroom teachers and six were PE specialists. All 269 children of these classes received an information letter of which 201 (74.7%) agreed to participate. Each child and a parent signed an informed consent. All research procedures were approved by the regional ethics committee.

Measurement procedures

Measurements were taken during an ordinary school week. The day prior to the measurements, children received an accelerometer and were asked to wear it during the following seven days during waking hours. They were asked to fill in a daily activity log that reported about the time the device was not worn. Teachers received a questionnaire to fill in during the measurement week, which included information about the class size, teacher specialty (classroom teacher vs. PE specialist), the physical activity behavior of the teacher and start and duration of the PE lessons. The size of each gym where the PE lessons took place was measured by the research team (Stanley long tape 60 m, Stanley Europe, Switzerland).

Accelerometer

To determine PA during the school week and especially during PE, children wore an accelerometer (3.5 x 3.5 x 1.8 cm) (GT1M, Actigraph LLC, Florida, USA) on an elastic belt around the hip. These devices measure acceleration of the body at a frequency of 30 Hz, integrate the filtered values over a selectable time interval (10 s in the present study) and store them to the memory of the device. Data were downloaded to a computer with the respective software (Actilife 5.7.4, Actigraph LLC, Florida, USA). Former studies have confirmed the reliability and validity of these devices (Janz, 1994).

Activity log

Children documented their date of birth, sex, height and weight, which they measured at home. They were also asked about the time of waking up and going to bed. These times were compared with the start and end of recorded accelerations to control if the accelerometer was worn. They were further asked to note times and reasons when and why they did not wear the accelerometer and time spent with biking as this activity is generally underestimated by accelerometers (Schmitz et al., 2005).

Questionnaire

Teachers were asked to document the start and duration of each PE lesson during the measurement week. They were also asked about the size of their class and their formation (PE teacher/classroom teacher). Two questions from the international physical activity questionnaire that were validated in German (Mäder et al., 2006) were used to ask about the duration and frequency of VPA during the week.

PE lesson content

Three different lesson contents containing 1. a training lesson of aerobic fitness, 2. a beginner's lesson in floorball and 3. a training lesson in acrobatics were given to the teachers to provide a similar basis to all classes for the estimation of the effects of the correlates. Twenty-nine PE lessons were analysed with regard to the factors that might influence PA during PE. Six swimming lessons during the measurement period were excluded from the analysis as the accelerometers could not be worn, as they are not water-resistant.

Data analysis

Accelerometer data of the whole week and during PE were separately analysed and classified as low, moderate or vigorous according to the cut-off points developed by Freedson et al. (2005). In six classes one PE lesson was replaced by a swimming lesson. As PA data during these lessons were not collected, PA data of the measured PE lessons were extrapolated for all classes to an average lesson time per week of 135 min (3 x 45 min) for the regression analysis to give the same weight to all classes. Average daily PA of children was determined by the counts/min measured with the accelerometer during waking hours. The accelerometer was considered not to be worn, if there were more than 10 minutes with continuous zeroes. These data sequences were eliminated for the analysis of total PA which is a regularly performed (Ekelund et al., 2004; Riddoch et al., 2004) and recommended (Ward et al., 2005) procedure in the literature. Imputation of data (Ward et al., 2005) was used if the children reported that they had to take off the accelerometer due to certain sport activities such as swimming or judo that could not be measured. These periods were found according to the respective times that were reported in the activity log and by visual checking of the data by the researcher. Imputation values were set to the lowest value of moderate activity provided by cut-off points (Freedson et al., 2005). For the time children reported to have spent in biking, mean accelerations during this period were determined. If it was higher than the cut-off for low-to-moderate activity, nothing was changed as it was assumed that the child was doing activities other than biking continuously during this period. However, when the mean of acceleration values during the biking was lower than the low-to-moderate cut-off, imputation of the lowest value of moderate activity provided by the cut-off points (Freedson et al., 2005) was performed as it was assumed that these children have been sitting on the bike a lot of the time and therefore acceleration was underestimated. A day was considered valid when accelerometer data contained at least eight hours of continuous measurements after data cleaning. Teacher's formation was coded by 0 for a classroom teacher and 1 for a PE teacher. Data are shown as mean \pm standard deviation unless stated elsewhere. The influence of the correlates on time spent in MVPA during PE was determined using multifactor linear regression analysis with backward imputation. To correct for varying units, all variables were z-transformed before their integration into the model. The criterion for the exclusion of a correlate was F-probability below 0.1. All analyses were performed using SPSS Package 19 and the significance level was set at $p < 0.05$.

Results

Data of 11 children were not used because of defective accelerometers or the child did not wear the device during PE. Data of 91 girls (11.1 \pm 0.9 y, 1.5 \pm 0.1 m, 37.6 \pm 7.6 kg) and 99 boys (11.2 \pm 0.8 y, 1.5 \pm 0.1 m, 37.7 \pm 8.9 kg) were included in the final analysis. Overall, children spent 649.9 \pm 45.3 min/d (85.6% of all activity) in low, 92.8 \pm 20.5 min/d (12.2%) in moderate and 16.9 \pm 9.1 min/d (2.2%) in VPA. The mean length of a PE lesson was 49.1 \pm 10.5 min with 29.1 \pm 7.9 min (59%) of low, 14.7 \pm 4.9 min (30%) of moderate and 5.4 \pm 3.5 min (11%) of VPA. Over the week, children spent 106.4 \pm 32.5 min in PE lessons of which 62.8 \pm 19.9 min/week (59.7% of all PE time) were low, 32.0 \pm 12.6 min/week (29.4%)

moderate and 11.6 ± 7.0 min/week (10.9%) vigorous PA. Average proportion of weekly MVPA during PE on total weekly MVPA was 3.1%. Ninety-nine children attended PE lessons provided by a classroom teacher (52%) and 91 (48%) children attended lessons provided by PE specialists. A mean class size included 20 ± 2 students. The size of gym was 363.1 ± 90.5 m² and average VPA of the teacher was reported to be 48.9 ± 22.9 min/d.

Univariate analysis revealed that the given personal factor sex ($R^2 = 0.14$, $p < 0.001$) explained most of the variance of MVPA during PE. Body weight ($R^2 = 0.02$; $p = 0.09$) explained some of the variance whereas age ($R^2 = 0.01$; 0.322) did not explain a significant amount of the variance of the model. Of the other factors, average daily PA ($R^2 = 0.13$, $p < 0.001$) explained most of the variance of PA during PE. Size of class ($R^2 = 0.06$; $p < 0.01$), activity behavior of the teacher ($R^2 = 0.03$; $p = 0.03$), teacher specialization ($R^2 = 0.02$; $p = 0.08$) and size of gym ($R^2 = 0.06$; $p < 0.01$) also had a significant effect on PA during PE. A model that included only given personal factors such as sex, weight and age explained 15.2% of the variance in PA during PE ($p < 0.001$, SEE = 10.4). However, the same amount of variance in MVPA during PE lessons ($R^2 = 0.152$, SEE = 10.4, $p < 0.001$) was explained when age was excluded from the model (Table 1) due to the inclusion of grade 4th to 6th children that provided a low variability in age (β -coefficient: -0.273 , 95%-CI: -2.341 , 1.797, $p = 0.795$).

When all tested factors were included in the model, 53.0% of the variability of MVPA during PE were explained by the final model ($p < 0.001$, SEE = 0.86) (Table 2). Therefore, 37.8% of the variance of time spent in MVPA during PE lessons were explained by factors other than sex, weight and age. Thereby, female sex, weight, age, size of class and PA of the teacher, activity behavior of

the children, teacher specialization and size of gym were positively correlated with time spent in MVPA during PE. Boys spent 7.42 min (CI: 10.10, 4.75 min; $p < 0.001$) more in MVPA. Children spent 3.76 min (95%-CI: 0.77, 6.74; $p = 0.003$) more in MVPA when the lesson was held by a PE specialist compared to a usual classroom teacher.

Discussion

The main goal of the study was to assess correlates of MVPA during PE that may help in finding effective intervention strategies to increase the insufficient amount of MVPA provided during PE (Pate et al., 2006). The model proposed in the present study comprising sex, weight, age and daily PA of children, class size, VPA and teacher specialization and size of gym explained 53% of the variability of PA during PE. PE taught in small classes by a specialized teacher in larger gyms was associated with increased MVPA during PE. In addition, children that were more active over the day, were also more active during PE lessons. Forty-one percent of the time measured during PE was spent in MVPA in the present study, which was lower than the 50% previously recommended (Pate et al., 2006). Therefore, adapting PE by correlates presented in the current study may help to achieve the recommended activity level during PE.

Levels of overall daily PA were comparable to observational (Bailey et al., 1995) and accelerometer-based studies (Riddoch et al., 2004; Meyer et al., 2011) while PE lesson time had been reported to be shorter (29.5–34.3 min) in US studies (McKenzie et al., 1995; McKenzie et al., 2000) but comparable to European studies (49.9 min) (Meyer et al., 2011) than our measured PE time (49.1 min), indicating that more PE lesson time is provided in our area than in US countries. Thereby, the amount of time spent in MVPA during an average PE lesson was higher (20.1 min) than in other studies that analyzed PA behavior during PE by observation (MVPA: 10.6–16.5 min) (McKenzie et al. 1995; McKenzie et al., 2000; Nader, 2003) or measured by accelerometers (MVPA: 16.7 min) (Meyer et al., 2011). However, relative values (41%) were comparable to these studies (32.8–48.5%). The same differences were found on weekly PE levels when our results were compared to former results (McKenzie et al., 1999). It is possible that during the observational measures of the previous studies, children's PA might have been measured less objectively, which may explain some of the differences. However, children attending longer PE lessons seem to accumulate more MVPA, which is especially important for the inactive children (Meyer et al., 2011). Levels of MVPA during PE were as in other studies (McKenzie et al., 1995; Nader, 2003; Meyer et al., 2011), lower than previously recommended (Pate et al., 2006). MVPA accumulated during PE over the week contributed only to a small part to the total weekly MVPA. Yet, it had been reported recently that during days that contained a PE lesson, 16.8% of the total time spent in MVPA was accumulated during PE lessons (Meyer et al., 2011). Therefore, augmenting the number of PE lessons increases the amount of total weekly MVPA. Thereby, the contribution of PE to total daily PA might be enlarged by not only increasing the relative amount of PA during PE lessons but also by increasing the amount of total PE lesson time.

Personal factors such as sex, age and body weight affect general PA behavior. In our study, sex had a large effect on PA during PE similar to previous studies (McKenzie et al., 1995; McKenzie et al., 2000; Nader, 2003). As boys are known to be more active than girls in regard to their general activity behavior (Riddoch et al., 2004), these findings seem also to be true for PA during PE. However, differences between sexes were abolished, when they were corrected for the biological age (Sherar et al., 2007), suggesting that daily PA and PA during PE might be more dependent on the maturity status than on sex. In addition and similar to another study (Riddoch et al., 2004), age was inversely related to total daily PA. This decline has also been more associated with biological maturity than with the chronological age (Sherar et al., 2007). Whether our decrease with age is fully explained by differences in matu-

	β -Coefficients (95% CI)	p value
Intercept	65.63 (58.1, 73.16)	< 0.001
Sex	-8.25 (-11.39, -5.10)	< 0.001
Weight (kg)	-0.18 (-0.37, 0.01)	0.063
Sex: 0 = male, 1 = female.		

Table 1: β -coefficients of personal correlates for children's MVPA (min) during PE (N = 190).

	β -Coefficients (95% CI)	p value
Intercept	120.52 (95.95, 145.09)	< 0.001
Sex	-7.42 (-10.10, -4.75)	< 0.001
Weight (kg)	-0.18 (-0.35, -0.01)	< 0.041
Age (y)	-2.16 (-3.93, -0.39)	< 0.011
Daily PA of children (counts/min)	0.03 (0.02, 0.04)	< 0.001
Size of class	-2.28 (-2.98, -1.57)	< 0.001
PA behavior of the teacher (min/d)	-0.11 (-0.16, -0.06)	< 0.001
Teacher spezialisation	3.76 (0.77, 6.74)	< 0.010
Size of gym (m2)	0.03 (0.01, 0.44)	< 0.002
MVPA = dependent variable (time regarded as moderate-to-vigorous activity by cut-off analysis during physical education (PE). CI = Confidence interval. Sex: 0 = male, 1 = female, Daily PA (physical activity) of children = average activity measured by the accelerometer over the week (counts/min). Class size = number of children in the class reported by the teacher in the questionnaire. Activity behavior of the teacher = hours in vigorous PA per day reported in the questionnaire. Teacher specialization: 0 = classroom teacher, 1 = PE specialist.		

Table 2: β -coefficients for correlates on children's MVPA (min) during PE (N = 190) with adjustment for age, sex and weight.

ration or whether there is also a maturity-independent age-related decline cannot be tested as we did not assess maturity stages. More studies have to be done to determine whether PA of girls and older children is generally independent of the content of the PE lessons or teachers' attitudes, as they are tackled less actively than boys and children of younger age. We still know very little about genetically based differences in PA between the sexes (Maia et al., 2002) or true longitudinal differences of PA with age (Nader et al., 2008). Children were more active, the less they weighed. PA has been shown to be higher in normal-weighted compared to obese children when corrected for maturity (Ekelund et al., 2004) suggesting that the decline in PA might in part be maturity-independent but weight-related. Daily PA behavior of the child is another important personal trait that highly influenced the time spent in MVPA during PE. It was evident that children that are generally more active during the day spent more absolute time in MVPA during PE. Whether this is related to genetic factors determining general PA behavior as suggested by Wilkin et al. (2004), or rather by a heterogeneous combination of personal, social and environmental factors (van der Horst et al., 2007) is open to debate. Whatever the reason, it is important to not only increase children's PA during PE lessons but also focus on leisure time PA as they might influence one another reciprocally (Meyer et al., 2011).

The present study is the first to relate class size together with other correlates to objectively measured PA. Class and gym size, daily PA of children, formation and PA behavior of the teacher explained a third of the whole variance in MVPA during PE lessons. In other words, PE provided in small classes by active PE specialists in larger gyms was beneficial in attaining more MVPA during PE, as suggested by others (Hastie and Saunders, 1991; McKenzie et al., 2000; Nader, 2003). Size of the gym positively influenced the PA of children during PE. Gyms measured in the present study were relatively large ($363.1 \pm 90.5 \text{ m}^2$) comparable to a floorball field of $24 \times 14 \text{ m}$ (336 m^2), but smaller than a volleyball field, which is $18 \times 9 \text{ m}$ (162 m^2). The gym size might even have a larger effect with more variability than found in the present study providing more variability for game plays that need larger space and allowing children to move more freely and extensively during games or unstructured play. The reason that children were more active in smaller classes may be due to more opportunities to practice uninterrupted and that children were more controlled and could not dodge exercise (Nader, 2003). Others argued that in larger classes more lesson time was spent in transition, most probably due to the larger number of students to organize and keep under control (Hastie and Saunders, 1991). The inclusion of PE specialists that are often physically active themselves has been shown to be effective at increasing PA during PE (McKenzie et al., 1995; Nader, 2003; Kriemler et al., 2011) with factors such as motivation of the children that may be influenced by enthusiastic teachers and better quality of the lessons that seem to be relevant.

Surprisingly, daily PA of the teacher was negatively related to the children's MVPA during PE. These findings might have resulted from misclassification of the self-reported VPA of the teachers by social desirability, a phenomenon well known in questionnaire-based research (Adams et al., 2005). On the other hand, less active teachers might have been more aware of the need to increase the activity behavior of the children and more active teachers may have been more interested in their own activity behavior. A previous study reported a positive but not significant relationship of PA of the teacher with MVPA of the children during PE (McKenzie et al., 1999). Therefore, it seems to be difficult to relate the teacher's self-reported PA to children's PA during PE. The low variability of the PA behavior of our involved teachers with all of them being physically very active might also have had an effect on the result. Therefore, teachers' PA should be measured more objectively in future studies and a wide variety of teachers should be invited into the study to overcome these limitations.

As is the case in non-randomized studies, selection might have been a weakness in this study as teachers generally interested in PE may have taken part more often. Therefore, the study results might not be generalizable for all teachers. On the other hand, the results

may have been even more pronounced by the inclusion of teachers without any interest in PE. Furthermore, teachers' PA was not objectively measured and may therefore have been biased by social desirability. This correlate should be assessed more objectively in future studies. The study focused on quantitative measurements only. The quality of the PE lessons such as the improvement of the children in their social behavior or the success in learning new motor skills enabling children to be more physically active has not been investigated.

The contribution of this study to previous studies focusing on PA during PE lessons is the documentation of relevant correlates of MVPA during PE based on objectively measured data and the investigation of a model summarizing significant correlates in a composite influence on MVPA during PE. The present study proposes an ideal setting of PE that should be taught in small classes and large gyms by specialized teachers that may even motivate children to be physically active outside the school setting. The relation between the children's PA during PE and overall PA may go in both directions and may influence one another supporting promotion on both ends. Findings should be considered in future PE monitoring and intervention studies, but also for political arguments in favor of more PE lessons, smaller PE classes, well-educated PE specialists, larger gyms and an increase in the overall daily PA of children.

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